CONCEPTUAL HYDROGEOLOGIC MODEL OF THE HEXCEL SITE

Hexcel Corporation
Former Hexcel Corporation Facility
Lodi, New Jersey

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1.0 INTRODUCTION

In a letter dated September 10, 1992, the New Jersey Department of Environmental Protection and Energy (NJDEPE) requested Hexcel to submit an "off-site receptor investigation report" for the Hexcel Corporation site in Lodi, New Jersey. The specific content and focus of this study was discussed between the NJDEPE and Killam during a meeting on August 27, 1992. As a result of this discussion, it was agreed upon that the study should be focused on the aquifer systems underlying the site, the hydraulic relationship between the aquifers and the adjacent Saddle River, and the impact on groundwater quality at the site.

In order to satisfy this NJDEPE requirement, a hydrogeologic model of the site has been developed and is presented herein. This conceptual model is the result of analyzing previously generated data including well logs, soil borings, water elevations, water quality samples, pumping test and slug test data and incorporating some new data such as one round of groundwater and river level elevation data.

2.0 HYDROGEOLOGIC DESCRIPTION OF THE SITE

Well logs and soil borings indicate that the upper overburden aquifer material includes fill and glacial alluvial sand and gravel, and ranges in thickness from seven to seventeen feet. The lower overburden aquifer material consists of silty sand and gravel. A four to fifteen-foot thick silty clay layer separates the upper and lower aquifers over most of the site. The clay layer is thickest (13 to 15 feet) in the central portion of the site near wells MW-3, MW-5 and PI-1 (Figure 1.) The silt and sandstone bedrock aquifer lies directly below the unconsolidated sands and gravels of the lower overburden, with a transition zone of weathered silt and sandstone forming the boundary between the two geologic formations. This bedrock is part of the siltstone Passaic Formation.

The clay layer appears to thin in the eastern region of the site. It is only 1.5 feet thick in the well log for MW-1, located near the southeast corner of the site. MW-1 is a deep well directly beside MW-17, a shallow well. Water levels in these two wells have historically been very similar, with the difference in water elevation ranging from 0.01 to 0.2 feet. This suggests that the upper and lower overburden can freely equilibrate with one another, and thus are in good hydraulic connection at this point. Five shallow wells on the eastern part of the site (MW-17, MW-22, CW-1, CW-2, and CW-6) were drilled to clay, but did not go deep enough to ascertain the thickness of the clay layer. Well CW-3 was drilled through the clay layer, which was determined to be 0.5 foot thick at that point. Two shallow wells (CW-4 and CW-5) did not intersect the clay layer. A 21-foot well, MW-20, installed east of the site on the other side of Main Street, also did not intersect any clay.

Eight well "pairs" have been installed at the site, with one well screened in the upper overburden and the other adjacent well screened in the lower overburden (MW-2 and 3, MW-4 and 5, MW-6 and 7, MW-8 and 9, MW-10 and 11, MW-12 and 13, MW-14 and 15, MW-17 and MW-1). Vertical and horizontal gradients were calculated for water elevations measured in the well pairs in January 1991 (by Heritage Remediation/Engineering) and September 1992 (by Killam Associates). Contour maps for the September 18, 1992 elevation data are presented in Figures 2 through 4. In general, the site displays upward and westward gradients near the Saddle River, downward gradients near Building Nos. 1, 2 and 4, and very small fluctuating vertical gradients on the eastern edge of the site adjacent to Main Street. The gradient of the upper overburden aquifer is westward near the Saddle River, but is strongly affected by a local high between Building Nos. 1, 2, 3 and Building No. 4, which creates a radial pattern in the eastern portion of the site. In addition, the basement of Building No. 1 is excavated to the clay layer, and thus the upper aquifer is missing there. Ground water flows around this obstruction, with some being diverted by seeping into the basement and ultimately being removed via the basement's sump pump. The horizontal gradient of the lower overburden aquifer is to the west and southwest. These observations are consistent with historical groundwater flow patterns. Note, however, that the sump in the basement of Building No. 1 is not in direct hydraulic connection with the aquifer system, and is therefore not used in the construction of groundwater contours, as was previously done by Heritage.

On September 18, 1992, a river staff gauge was installed near the southwestern corner of the site and river elevations were noted (Figure 2). The surface of the Saddle River at the staff gauge was 18.01 feet above Mean Sea Level (MSL) on September 18, 1992. Heritage has previously reported that in December 1990, the water surface at the north end of the site was 19.4 ft. MSL, and 18.4 ft. MSL at the south end (Heritage, 1991a). The river bed elevation varies from 17.9 feet at the north end of the site to 15.8 feet at the south end. The screened interval of the upper overburden monitoring wells along the river extends from 16.26 ft. MSL at MW-8 (lowest bottom of screen) to 27.83 ft. MSL at MW-10 (highest top of screen). The screened interval of the lower overburden monitoring wells along the river extends from 0.78 ft. MSL at MW-11 (lowest bottom of screen) to 13.77 ft. MSL at MW-15 (highest top of screen). Thus the shallow wells are screened at depths comparable to the river, while the deep wells are screened below the river.

Water levels in the shallow wells adjacent to the river, on available dates (August 1988, January 1991, July 1991, September 1992) varied from 18.13 to 19.59 ft. MSL. Corresponding water levels in the deeper wells varied from 20.46 to 22.21 ft. MSL, indicating confined conditions. There is a net hydraulic gradient from the lower aquifer to the upper aquifer and to the river. The elevation of the water table on the western edge of the site is higher than the river's surface water. The difference in elevation between the river surface and the water level in the shallow monitoring well closest to the river staff gauge was 0.34 feet on September 18, 1992. Thus, the hydraulic gradient in the western-most portion of the upper overburden aquifer is toward the adjacent river.

3.0 HYDRAULIC TESTING

A number of pumping tests have been conducted at the site, involving wells located in the upper overburden, lower overburden, and bedrock formations. Data were available for three pumping tests of the upper overburden: a 72-hour test of CW-5, a 27-hour test of RW7-5, and a 2-hour test of CW-21. A 24-hour pumping test was performed on the lower overburden at well PI-1, and another 24-hour test was performed on the bedrock production well. Each of these pumping tests and a number of slug tests performed on both the upper and the lower overburden aquifers are briefly discussed below.

3.1 Upper Overburden Aquifer

3.1.1 Pumping Tests

Pump test data for the upper overburden aquifer were given in several monthly project status reports (Heritage, 1990, 1991b, 1991c). In the longest pumping test of the upper overburden, control well CW-5 was pumped at 0.75 gpm for 72 hours while nearby wells CW-6, MW-20, and MW-22 were monitored for water elevations. The resultant data were not analyzed by Heritage (1991b). The report stated that observation wells CW-6, MW-20, and MW-22 did not exhibit a response to pumping in well CW-5, which showed a drawdown of 3.5 ft. Killam's review of the plotted data revealed that the wells did in fact respond to pumping of CW-5. Killam's analysis of the data and our conclusions are discussed herein. Actual tabulated data were not provided in the Heritage report. However, sufficient information for analysis was obtainable from depth versus time curves included by Heritage as a figure.

Wells CW-5, CW-6, and MW-20 were screened in similar intervals, but the top of the MW-20 screen was 4.22 feet below the bottom of the CW-5 screen. This was the only pumping test conducted on the east side of the site, near the intersection of Main Street and Molnar Road; all other tests involved pumping wells located west of Building Nos. 1, 2, and 3.

First, Cooper and Jacob (1946) semilog time-drawdown and distance-drawdown methods were applied to the pumping test data. However, the critical u values were greater than 0.05, which indicated that the results would have unacceptably high errors. Therefore, the Theis (1935) log-log methods were explored. However, since the same Heritage figure presented plots for the pumped well in addition to the observation wells, the plot for MW-20 was too flat and imprecise to be analyzed by curve matching. Time-drawdown graphs for CW-6 and MW-22 (Appendix 1) were constructed. Their mean transmissivity (T) was 394 gpd/ft.; mean storativity (S) was 0.102. As a check, drawdown data were plotted against the square of the distance, in a log-log plot. This plot was analyzed using the Theis non-equilibrium method (curve matching against a graph of W(u) versus u), yielding values of 934 gpd/ft. transmissivity and 0.0499 storativity.

In the second pumping test of the upper overburden aquifer, recovery well RW7-5 was pumped at 0.95 gpm for 27 hours, and drawdowns in seven recovery wells (RW7-1, 2, 3, 4, 6, 7, 9), two shallow monitoring wells (MW-6, 12), and two lower overburden (deep) monitoring wells (MW-7, 13) were measured. Minimal drawdown was observed in MW-12, but all other shallow wells exhibited responses to pumping. The two deep wells experienced drawdown also, but it was not apparent to what stimulus they were reacting. Drawdown in the deep wells occurred during the first five hours of pumping, then the wells quickly recovered. Drawdown occurred again after 23 hours, then recovery. Both wells were drawing down a third time when the pump at RW7-5 was shut off. It is possible that they were responding to sporadic pumping of the bedrock production well. No information on that day's schedule of production well pumpage was available to confirm this. However, during the later pumping test of the bedrock production well, both MW-7 and MW-13 showed strong responses to the pumping. Thus it seems likely that pumping the bedrock well could have been the cause of the behavior of these two deep wells during the shallow aquifer pumping test at RW7-5.

Heritage presented the drawdown data in tables and graphs and made qualitative assessments of the results, but did not perform any quantitative analyses. Killam utilized this data to quantitatively assess the recharge to the upper overburden and to estimate values for aquifer transmissivity and storativity.

The recharge effect of the Saddle River was investigated using data from the RW7-5 pumping test. All wells exhibited flatter drawdown curves with increasing time, indicating recharge conditions. After 25 hours of pumping, wells closer to the river (40 to 50 ft.) experienced less drawdown than comparable wells farther from the river (70 to 80 ft.). For example, wells RW7-3 and RW7-6 are located at similar distances from the pumping well (54 and 51 feet, respectively), however the well closer to the river, RW7-6, had only 15% as much drawdown as RW7-3. Likewise, wells RW7-4, RW7-7, and RW7-9 are all located at 24 to 28 feet from the pumping well, but the two wells closer to the river, RW7-7 and RW7-9, experienced only 60% and 34%, respectively, of the drawdown seen in RW7-4. The Law-of-Times analysis (Walton, 1988) was applied to the data to locate the source of recharge. The results (Appendix 2A) indicate that recharge is coming from a region that ranges from 28 feet east to 20 feet west of the river's eastern bank. This suggests that the upper overburden aquifer, under pumping conditions, received recharge from the river.

Shallow observation well data were analyzed using semilog time-drawdown and distance-drawdown curves (Cooper and Jacob, 1946). However, u values ranged up to 0.392 and were unacceptably high for the general application of this method. The seven shallow wells which exhibited Theis-like behavior (MW-6, RW7-2, RW7-3, RW7-4, RW7-6, RW7-7, RW7-9) therefore were analyzed using log-log time-drawdown curves (Theis, 1935) to yield values for transmissivity and storativity of the upper overburden near RW7-5. All of the observation wells exhibited about 0.1 ft. recovery toward the end of the pumping test. One likely explanation for this is the rainfall which occurred late in the test. There also may have been an antecedent rising trend in the water table that was not quantified and therefore went uncorrected. The log-log plots (Appendix 2B) produced geometric mean values of:

$T_{g.m.}$ = 289 gpd/ft., {95% C.I.: 209 to 398 gpd/ft.}
$S_{g.m.}$ = 0.00453, {95% C.I.: 0.00212 to 0.00966}

This transmissivity was on the same order of magnitude as that calculated for the eastern edge of the site, displaying good agreement between the results of the two tests. The storativity values bridge the accepted ranges of confined ($S = 10^{-5}$ to 10^{-3}) and unconfined (S = .01 to .3) conditions. These low values are attributed to delayed yield due to lower vertical permeability of the sediments. However, the various methods (Neuman, 1975) normally employed to quantify this cannot be applied because the late drawdown data are confounded by the recharge effect and the early drawdown was not recorded.

In the third pumping test of the upper overburden, control well CW-21 was pumped at 2 gpm, and water levels were monitored in nearby wells CW-20, CW-22, and MW-28. These wells were between 16.5 and 18 feet from the pumping well and screened over similar intervals. The pumping test was terminated after two hours due to failure of the pump's air diaphragm. Because of the shortness of the test, drawdowns were very small (.08 to .31 feet) and the data were insufficient to perform quantitative analyses. However, a few qualitative observations could be made. By the end of the two hours, more drawdown was seen in the wells south of CW-21 (CW-20 and MW-28). The well closest to the river (MW-28) showed intermediate drawdown, indicating that the heterogeneity of the media may override the river's recharge effect at early pumping times.

3.1.2 Slug Tests

Transmissivity estimates based on slug test hydraulic conductivities were calculated by Heritage for all 22 control wells yielding an average value of 358 gpd/ft.. (Heritage, 1990). This value closely agrees with those calculated by Killam using the two long-term pumping tests done by Heritage. The associated conductivity for this range of transmissivity is typical of uniform fine sand (Cedergren, 1989). Upper overburden borings encountered fill, sand, and gravel in various combinations.

3.2 Lower Overburden Aquifer

3.2.1 Pumping Test

A 24-hour pumping test was performed on the lower overburden at well PI-1 by Heritage. Data for the 24-hour pumping test of well PI-1 were provided in the Lower Overburden Aquifer Injection Well Feasibility Report (Heritage, 1992a). Pilot well

PI-1 was pumped at 4 gpm for 24 hours and water level measurements taken in eight lower overburden monitoring wells. More drawdown was observed in wells south of the pumping well (MW-3, 9, 11) than in the wells to the north and east of the pumping well (MW-5, 15, 19, 26), indicating anisotropy in the sand and gravel media. MW-13, at 100 feet northeast of PI-1, experienced drawdown similar to MW-3, at 203 feet southeast of the pumping well.

Heritage (1992a) analyzed the data using Cooper and Jacob (1946) distance-drawdown graphs. Heritage paired each monitoring well with the pumping well to yield a straight line between the two data points, an unusual application of the technique. Additionally, using drawdown data from the pumping well is only appropriate for an idealized 100% efficient well, but Heritage reported that PI-1 was only 12% efficient. The resultant average value of transmissivity of 467 gpd/ft. is low compared to the value estimated by Killam. Killam reanalyzed the data using more appropriate techniques, as discussed below.

The drawdown versus time graphs for both PI-1 and MW-9 displayed a sharp increase in slope after 30 minutes of pumping, then a decreasing slope after 90 minutes. Heritage (1992a) attributed this behavior to the cone of depression expanding to encounter a less permeable boundary followed by a recharge area. However, close inspection of the original data reveals that the pumping rate increased from 4 gpm to 5 gpm during the first hour, then returned to 4 gpm by the second hour. This change in pumping rate is the more likely cause of the unusual drawdown curves. Analysis of observation well drawdown (Cooper and Jacob, 1946, for the four with u values less than .05; Theis, 1935, for the others) yielded values for transmissivity and storativity of the lower overburden (Appendix 3A). Some of the plots showed poor quality data, MW-26 in particular. The geometric means, excluding data from MW-26, were:

$T_{g.m.}$ = 9400 gpd/ft., {95% C.I.: 7240 to 12200 gpd/ft.}
$S_{g.m.}$ = 0.00450, {95% C.I.: 0.00255 to 0.00793}

As a check, MW-9 datalogger recovery data (Appendix 3B) were analyzed using both residual drawdown and calculated recovery methods (Driscoll, 1986). The resultant transmissivities were 10,178 gpd/ft. and 8,516 gpd/ft., respectively. Storativity was determined in the latter method to be 0.00440. Since the drawdown curves were marred by inconstant pumping rates, the recovery data probably yield more accurate measures of the aquifer properties.

In summary, comparison of the results of the overburden pumping tests indicates that transmissivity in the lower overburden is about twenty to thirty times greater than transmissivity in the upper overburden. The hydraulic conductivity associated with this transmissivity, assuming a ten foot thickness, is characteristic of clean sand or silty sand (Freeze and Cherry, 1979). If one considers the probable contribution of the bedrock aquifer, the combined thickness of the formation would be greater than 200 feet. The combined transmissivity of the lower overburden and the bedrock should equal the sum of the individual transmissivities of those two units. The resultant average conductivity would then be lower, placing it in the range of the fractured siltstone which underlies the site. Because lower overburden borings indicated silty sand and gravel, it is difficult at the present time to determine the relative contributions of the overburden and bedrock units to the overall transmissivity. The storativity range indicates confined conditions.

3.2.2 Slug Tests

Some estimated transmissivities based on slug tests performed at seven lower overburden monitoring wells (MW-3, 5, 9, 11, 13, 15, 19) by Heritage yielded an average value of 1320 gpd/ft.. (Heritage, 1992a). This is an order of magnitude less than values calculated by Killam from the pumping test. The difference is due to Heritage's analysis of the slug test data while considering the lower overburden as an isolated aquifer and without considering its hydraulic connection to the bedrock below.

3.3 Bedrock Aquifer Pumping Test

Data from the bedrock aquifer pumping test, packer test, and chemical analyses were presented in the Bedrock Aquifer Characterization Report (Heritage, 1992d). The production well, screened from 38 to 240 feet below grade, was pumped at about 140 gpm for 24 hours and water level measurements were taken in fourteen observation wells. Four of the wells were screened in the upper overburden; ten were in the lower overburden. The deepest of the observation wells, PI-1, reaches the depth of 32 feet below grade, extending only four feet into the bedrock formation. Because of the over 100 feet of vertical distance between the center of the pumped interval and the bottom of PI-1, quantitative analysis of the data is problematic. Few analytical methods are appropriate for this well configuration, and even a method which allows for partial penetration of wells (Hantush, 1961) yielded imprecise and probably inaccurate results when applied by Killam to these data sets (Appendix 4). Nonetheless, qualitative information can be gleaned from the test data. The ten lower overburden wells all responded to pumping, indicating that they were in hydraulic connection with the bedrock aquifer. As expected, drawdown decreased with increasing horizontal distance from the pumping well. Based on currently available information, it is clear that the bedrock formation and the lower overburden sand and gravel formation are both part of the same hydrogeologic unit.

The relative contributions of the bedrock and the lower overburden to the overall transmissivity of the lower aquifer system cannot be determined with the current set of data. The values calculated from the pumping test of the lower overburden at PI-1 are probably overestimated for the lower overburden alone and underestimated for the aquifer as a whole. The slug tests of the lower overburden, which gave transmissivities an order of magnitude less than those calculated from the pumping test, support this interpretation. Because slug tests affect only a very localized region, they are probably more representative of the lower overburden itself without the bedrock effects seen in the pumping test. Based on this information, it can be estimated that the lower overburden's contribution is about one tenth, with the remainder of the transmissivity coming from the bedrock. Due to the vertical anisotropy of the formation, partial penetration of the observation wells, and inconstant pumping rates for the production well, more accurate quantitative analysis is impossible with the data presently available.

During the production well pumping test (Heritage, 1992d), drawdown curves for the lower overburden wells plotted against time showed slope reductions typical of recharge conditions after 20 to 200 minutes of pumping. This recharge effect occurred earlier at wells closer to the river than at wells on the eastern portion of the site. Thus it seems more likely that the river is the recharge source and not the upper overburden aquifer. Although the clay layer lies at or below the river bottom, it is possible that thinning or silt lenses compromise its resistance to flow under the river bed. Another possible explanation for the reduction in slope of the drawdown curves is that the effect of partial penetration becomes constant after long periods of time, and the change of slope reflected the cessation of further curve displacement.

The two shallow wells located in the central area of the site (MW-4 and MW-12) exhibited no response to pumping the production well, indicating that the clay layer between the upper and lower overburden was forming an effective barrier. Conversely, well MW-20 (a 21 ft. deep well located on the east side of Main Street) where no clay was encountered, did show drawdown. In addition, the eastern well pair (shallow well MW-17 and deep well MW-1) experienced almost identical water levels, suggesting that the upper aquifer was in good hydraulic connection with the aquifer below. The well logs, which displayed a thinning of the clay layer in the eastern part of the site, support this interpretation.

4.0 CONCEPTUAL HYDROGEOLOGIC MODEL

In summary, our conceptual model of the site's hydrogeology is as follows:

1. The system consists of two aquifers separated by a clay layer over most of the site.

2. The system consists of a single aquifer on the eastern part of the site where the clay layer thins out.

3. The upper, unconfined aquifer, also called the upper overburden aquifer, is composed of heterogeneous fill and glacial alluvial sand and gravel.

4. The lower, confined aquifer consists of two geologic formations:
   (i.) Lower overburden formation of silty sand and gravel, and
   (ii.) Siltstone bedrock of the Passaic Formation.

5. The silty clay confining layer is located at 7 to 17 feet below the ground surface and varies in thickness from 15 feet, in the south and central part of the site, to zero on the eastern side of the site.

6. The vertical gradient between the two aquifers is upward near the Saddle River and downward near Building No. 1 and Building No. 4.

7. The horizontal gradient is to the west and southwest in the lower aquifer; in the upper aquifer, it is westward near the river and radial near Building Nos. 1 and 4.

8. Saddle River is a gaining stream in the area of the site. The lowest point along the river channel is at a higher elevation than the top of the clay layer, such that the upper aquifer is probably in direct connection with it.

9. The upper aquifer discharges to the river, and is recharged by the lower aquifer near the western boundary of the site.

10. Transmissivity of the lower aquifer is about twenty to thirty times that of the upper aquifer. The transmissivity of the lower aquifer may be primarily controlled by the bedrock's transmissivity. The horizontal hydraulic conductivity of the upper overburden aquifer is greater than that of the lower overburden.

5.0 IMPACT ON GROUNDWATER QUALITY

A comparison of groundwater quality data between the upper overburden and the lower overburden aquifers (Environ 1988) showed that total volatile organic (VO) contamination detected in the lower aquifer wells was often two to five orders of magnitude lower than corresponding levels found in the upper aquifer. This relationship varied somewhat with location.

The highest VO concentration in the lower aquifer (6.535 mg/L) was detected at MW-1 (in July/August 1988) on the eastern part of the site where the intervening aquitard is of doubtful integrity and a slightly downward vertical gradient exists. The adjacent shallow well MW-17 showed a total VO concentration of 844.92 mg/L in January 1989 (Heritage 1991d).

The second highest concentration in the lower aquifer was detected in MW-3 at 0.904 mg/L. Adjacent shallow well MW-2 showed a comparable VO concentration (0.990 mg/L) during the same sampling round (July/August 1988). Note that the deep well MW-3 is located directly downgradient of the most contaminated deep well MW-1.

The well pair MW-4 and MW-5 located east of Buildings 1, 2, and 3 in an area with a relatively thick clay layer, showed total VO concentrations differing by three orders of magnitude (shallow well MW-4 at 232.79 ug/L and deep well MW-5 at 0.603 mg/L) in July/August 1988. Similarly, well pair MW-6/MW-7 located west of Buildings 1, 2 and 3, also in an area with a relatively thick clay layer, showed a difference of three orders of magnitude in the total VO concentrations (MW-6 at 239.6 mg/L and MW-7 at 0.144 mg/L) in July/August 1988.

In two western well pairs (MW-8 and 9, MW-10 and 11), located in areas with upward hydraulic gradients, total VOs again differed significantly between the shallow and the deep wells. Total VOs detected in these wells in July/August, 1988, were 120.46 mg/L in the shallow well MW-8 and 0.043 mg/L in the adjacent deep well MW-9, 9.456

mg/L in shallow well MW-10 and 0.066 mg/L in the adjacent deep well MW-11. The other western well pair MW-14 and MW-15, showed very low levels of VO in both wells (0.010 mg/L in shallow well MW-14 and 0.024 mg/L in the adjacent deep well MW-15). Similarly, the well pair MW-12 and MW-13 located north of Buildings 1, 2, and 3 showed very low levels of total VO in the upper overburden well at 0.033 mg/L and in the lower overburden well at 0.131 mg/L (0.076 mg/L in duplicate).

It is significant to note that deep well MW-19 showed a Trichloroethene (TCE) concentration of 0.058 mg/L in January 1989. This well is located on the extreme northern end of the site and is not located downgradient of any documented impacted areas on the site. The presence of TCE in this well brings up the possibility that there may be an offsite contribution to the VOs noted in the lower overburden wells and the bedrock production well. Contamination of the bedrock aquifer by chlorinated volatile organics including TCE and its breakdown products in the areas of Lodi and Garfield has been documented and is on record with the NJDEPE.

Isopleth maps of chemical data from July 1988 through November 1990 for the shallow and deep aquifers (plates from Heritage, 1991d, and Heritage, 1992b, respectively) support the hydrogeologic model presented earlier. The total VO isopleth in the shallow aquifer shows the highest concentrations in an elongated plume stretching northwest to southeast, from the Saddle River to Main Street. This trend is consistent with the groundwater flow pattern shown in Figure 2 and the location of possible source areas east and west of Building No. 2. The corresponding deep aquifer isopleths showed a circular plume centered in the southeast part of the site, near MW-1. Given the stratigraphy and the local ground water gradient, it is likely that a portion of the shallow plume developed in the southeast direction (along the direction of groundwater flow) within the upper aquifer and, where the clay layer thins out, descended into the lower aquifer. The contamination noted in deep well MW-3 can be explained by the fact that the horizontal gradient in the lower aquifer is to the southwest, placing MW-3 directly downgradient of MW-1.

Based on the discussions contained in this report, it is our opinion that a fairly comprehensive understanding of the two aquifer systems has been achieved. Furthermore, it is our opinion that contamination in both the upper and lower overburden/bedrock aquifers has been adequately delineated. It has been demonstrated that the lower overburden aquifer is in hydraulic connection with the bedrock aquifer. As such, the lower overburden/bedrock aquifer has been investigated by the installation of nine (9) monitoring wells. No further proposals for delineation are considered to be warranted. The focus of this project will henceforth be directed towards free product removal and achieving hydraulic control over the contaminant plume(s) identified on the site.

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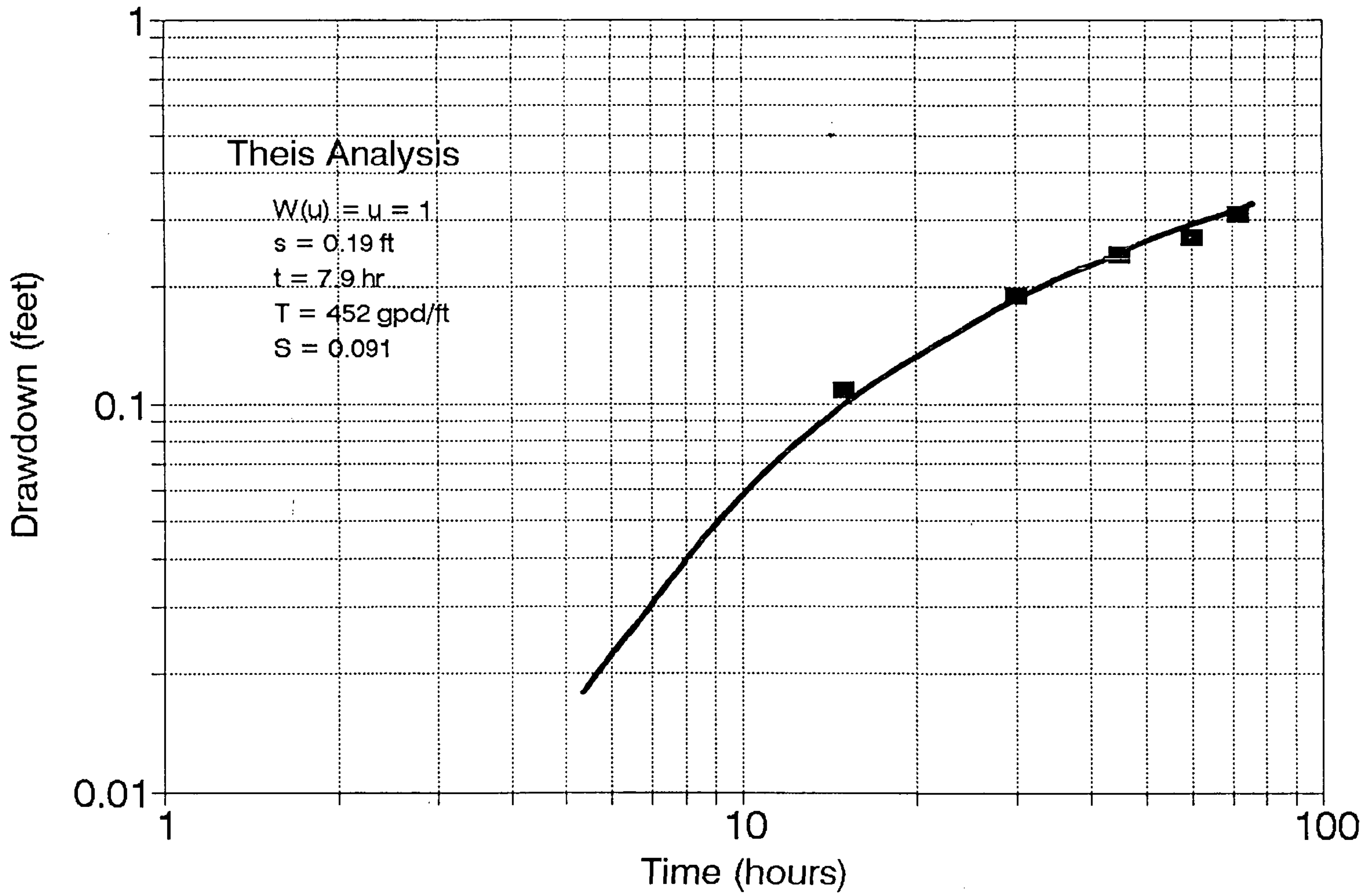
APPENDIX 1

Hexcel Upper Overburden
72-hour pumping test of CW-5

Hexcel Upper Overburden, 72-hour test
Response of CW-6 while pumping CW-5



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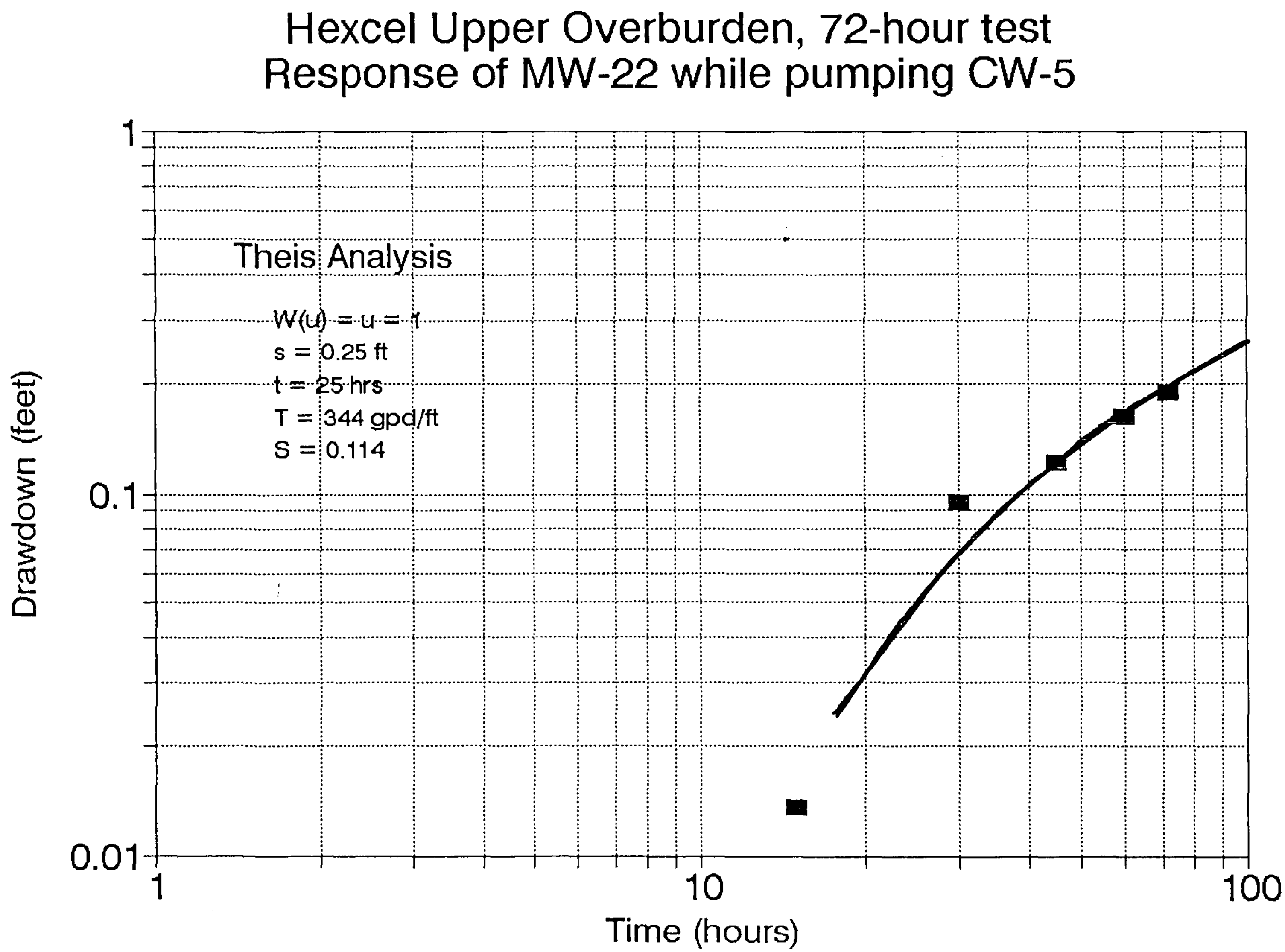
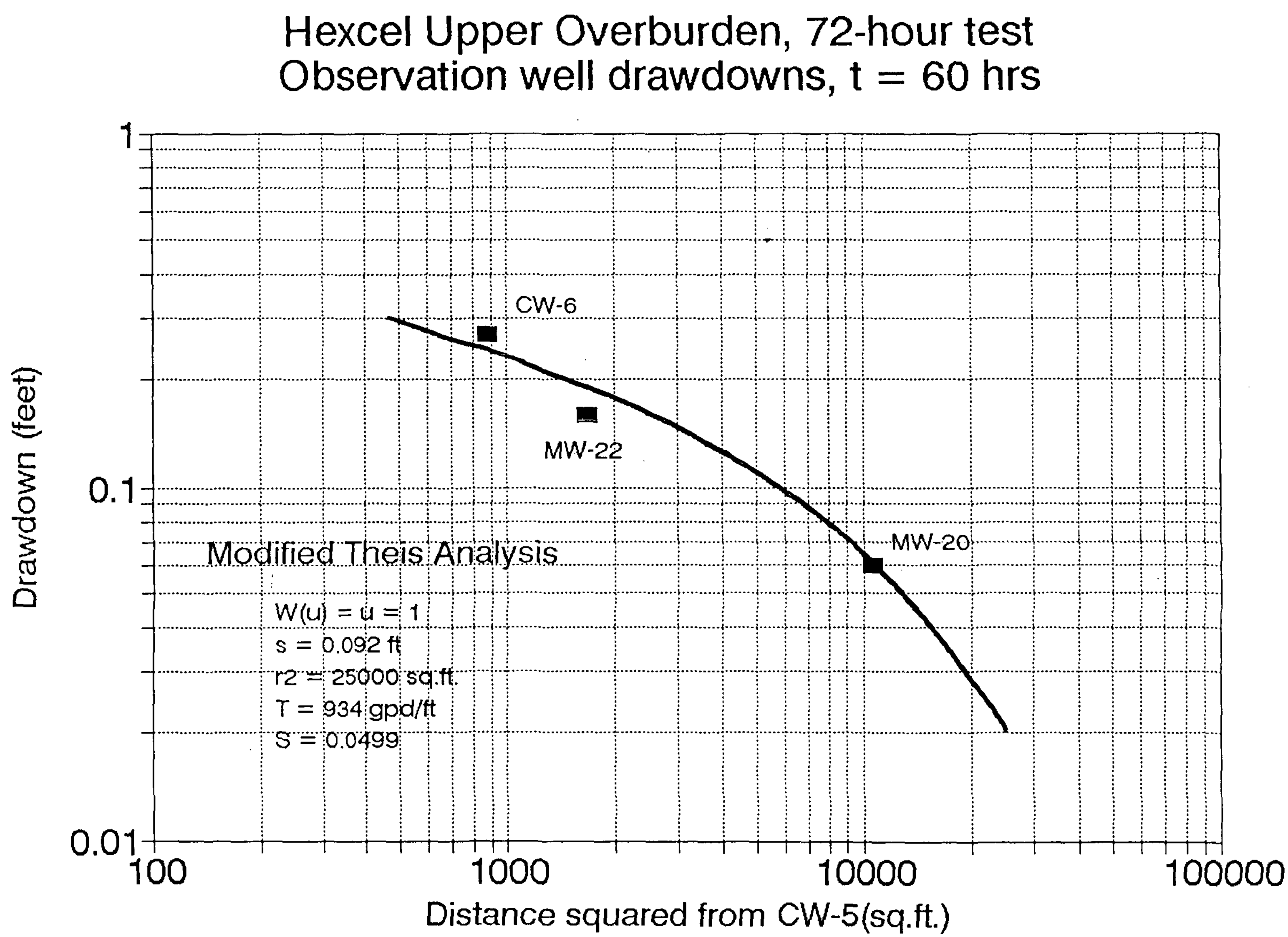


1-2

884010023


Hexcel Upper Overburden, 72-hour test
Observation well drawdowns, t = 60 hrs
Drawdown (feet)
1
0.1
0.01
100
1000
10000
100000
Distance squared from CW-5(sq.ft.)
CW-6
MW-22
MW-20
Modified Theis Analysis
W(u) = u = 1
s = 0.092 ft
r2 = 25000 sq.ft.
T = 934 gpd/ft
S = 0.0499

884010024

Killam

APPENDIX 2

Hexcel Upper Overburden
27-hour pumping test of RW7-5

A. Recharge zone based on Law-of-Times
B. Graphs of drawdown with respect to time